

Syllable Chunking in Zebra Finch (*Taeniopygia guttata*) Song

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We examined how 61 young zebra finch (*Taeniopygia guttata*) males copied song from 5 adult tutors. Zebra finch song consists of a string of 5–15 distinct syllables, and these syllables were copied as *chunks*, or strings of consecutive syllables (modal length = 3). The silent interval between 2 syllables was copied as part of the syllable after the silence. Copied chunks had boundaries that fell at consistent locations within the tutor's song, marked by a relatively long intersyllable silent period, a transition between call-like and noncall-like syllables, and a tendency for the tutor male to stop his song short. Young males also tended to break their songs off at the boundaries of the chunks they had copied. Chunks appear to be an intermediate level of hierarchy in song organization and to have both perceptual (syllables were learned as part of a chunk) and motor (song delivery was broken almost exclusively at chunk boundaries) aspects.

Information within a sequence is recalled more easily if it is organized into chunks composed of individual tokens. Studies on humans (Miller, 1956; Simon, 1974) have shown that groups of items that can be considered a single unit are learned as quickly as a single item. The ability to organize information into chunks is not restricted to humans. Terrace (1987) showed that pigeons learn sequences of five items more rapidly when such sequences can be organized into two chunks of items with different modalities. A difficulty with this approach to chunk formation is that the items are specifically grouped by the experimenter; presumably, the ability to form and recognize chunks was originally developed for processing naturally occurring stimuli. One such stimulus is bird song, which is produced after being retained in memory (Marler & Peters, 1982) and which consists of strings of units that are usually given in a specific order. Such strings can presumably be organized by individual birds into hierarchies of units.

Although each songbird species may have its own rules for organizing song and a common terminology may be inappropriate, researchers use such terms as *note* and *syllable* for subunits of song. However, defining the basic elements of song can be difficult because the length, organization, and phonetic structure of song varies widely among songbird species. The traditional approach is to examine sonograms or oscillograms and use markers, such as the intervals between acoustic elements, any sharply defined changes in frequency and frequency modulation, to demarcate song units (Güttinger, 1979; Isaac & Marler, 1963; Thorpe, 1958). Longer silences or changes in repeated patterns of sounds can be used to define higher order song units. When the song consists of a string of dissimilar elements, comparisons of song variants given by individual birds in different populations can be used to define internal units of song organization (e.g., Marler & Tamura, 1962).

Other approaches are possible. Cynx (1990) used a strobe flash to interrupt zebra finch song and showed that the basic motor units of song do, for the most part, correspond to syllables defined by the examination of sonograms. By noting the songs that young nightingales copied from tutor tapes and then examining the sequence in which the learned songs were delivered, Hultsch and Todt (1989) showed that packages of songs within the tutors' repertoires were learned and that during song delivery a learned song maintained its associations with other songs from the same package.

Zebra finches raised in group aviaries (Williams, 1990) or with sequential tutors (ten Cate & Slater, 1991) usually acquire their songs by copying strings of syllables from more than one tutor. In this study we examine the songs of young males raised in an aviary with several adult tutors and attempt to derive rules for within-song syntax by noting how the groups of syllables that were extracted from tutors' songs were subsequently organized in the young birds' songs.

Method

Subjects

Twelve adult male zebra finches (*Taeniopygia guttata*), raised in an in-house breeding program or obtained from commercial sources, were recorded and then introduced with a like number of females into an aviary at the Rockefeller University Field Research Center (Dutchess County, New York) in August 1986. The enclosed, indoor aviary (4 m wide × 2 m high × 2.5 m deep) was maintained on a 12:12-hr light:dark cycle and provided with 12 nestboxes, a large number of perches, nesting material, and water and seed ad libitum (see Williams, 1990). Over the next 2 years, 63 male offspring hatched and were raised to sexual maturity without experimental manipulation. These young males developed normal zebra finch songs, strings of 5–15 distinct syllables delivered in a stereotyped order, usually copied from more than one adult (see Williams, 1990). Five of the 12 individual adult males' songs were each copied, usually in part, by at least 9 young males (adult male GW was copied by 9 young males, RWB/O by 19, Y by 12, LG by 25, and LBY by 28), and those 5 adult males' songs and their 61 (recall that young males often copy from more than one tutor) copiers' songs were used in statistical analyses. The other 7 adult males were copied by 5 or fewer young males and were excluded from analysis because the number of chunks

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copied from each of these males' songs was too low to provide a good sample for describing song units. The difference in adult males' salience as song tutors is discussed elsewhere (Williams, 1990).

Song Recording

Songs were recorded with a Marantz (Chatsworth, CA) EC-7 microphone either at 3¼ in./s on Scotch (St. Paul, MN) Dynarange tape with a Tandberg (Norway) Series 15 reel-to-reel recorder or at 1½ ips on Scotch XS II tape with a Marantz PDM 201 cassette recorder. Quality of recordings made on these two systems is comparable (see Williams, Cynx, & Nottebohm, 1989). Males were caged individually for 1 week before they were recorded, and all songs were directed to a female. At least 10 song bouts were recorded, and males that did not sing readily were recorded on two occasions.

Song Analysis

The most complete song, including introductory notes, for each individual was digitized at 22 kHz with MacRecorder (Farallon, Emeryville, CA). Sonograms were produced with SoundEdit (Farallon; 128-point Fast Fourier Transform high contrast) on a Macintosh II computer. Printed sonograms produced in this manner are comparable to those generated by the Kay Digital Sonagraph with the 300-Hz filter.

Syllables within the young and adult males' songs were then delineated. To separate syllables we used silent intervals, abrupt changes in sound morphology, and high-low-high transitions in amplitude. Hence, we broke up complex syllables that are not separated by silence and may be treated as single syllables elsewhere. Although such complexes may in some cases be single syllables, birds often appear to treat the units within a complex as syllables, copying the smaller units within the complex independently (see Williams, 1990) and breaking song production between units within a complex (Cynx, 1990). We then matched the young males' syllables to those in the tutors' songs. In doing so, we defined sets of contiguous syllables learned from the same adult tutor's song as *copied chunks*. When no obvious match between a young bird's syllable and any of the tutors could be made, the syllable was labeled as improvised and not attributed to a chunk, and so not used in the analysis reported herein. Syllable morphology and sequence, including the length of silent intervals between syllables and the timbre of syllables (see Williams et al., 1989), were used to define which tutor was the *source* for a syllable. If timing and syllable phonology were not sufficient to distinguish between tutors with nearly identical songs, the most conservative choice was made: The syllable was designated as being copied from the song that contributed the adjacent syllable or syllables. We felt that such a conservative approach might miss some boundaries between copied units but would not introduce spurious fragmentation of songs. The chunks and boundaries described by our method are clearly defined and robust, and they are reliably and easily spotted by naive observers (see Figure 1). Our interobserver concordance was >90% in working independently; when we disagreed, reexamination usually revealed that one of us was clearly in error. When differences in scoring were not attributable to error, we excluded that portion of the song from the analysis, which made our effective agreement on scoring 100%. By these methods we described a total sample of 171 copied chunks, an average of 2.8 for each song.

Zebra finches occasionally start songs at points other than the first syllable and end songs at points other than the last syllable (Sossinka & Böhner, 1980). For each bird we examined several song bouts to determine where and how often a song was broken during production (see Figure 2); such points were called *production breaks*.

A chunk has two boundaries: a *beginning*, marked by the initial syllable in the chunk, and an *end*, marked by the final syllable in the chunk. Similar terminology was used to define the location of breaks in the song during production; such breaks were bounded by the final syllable of one chunk and the initial syllable of the unsung chunk.

Chunk boundaries and production breaks were further described by tabulating (a) the position within the song (number of song syllables before and after the boundary or break), (b) the length of the silence between the two syllables adjacent to the boundary or break (measured in ms, to a resolution of 1 ms, in three songs and then averaged), and (c) the type and class (defined as follows) of the two syllables adjacent to the boundary or break.

Syllable type: Phonology. All syllables were designated as one of five types (see Figure 3 for examples of each type): *downsweep*, a syllable consisting mainly of multiple harmonics that decreased in frequency during delivery; *stack*, multiple harmonics with little frequency modulation; *click*, a train of notes so sharply modulated as to appear as vertical lines on the sonogram; *high note*, a syllable with few (1–3) components, and the highest-amplitude component at >2 kHz; and *other*, any syllable that did not fall into one of the above categories.

Syllable class: call versus noncall. Many zebra finch song syllables are similar to the unlearned calls that both sexes produce (Price, 1979). A syllable was defined as *call-like* if it was either a stack or a downsweep and did not have timbre manipulations that depressed the amplitude of any of the lower three harmonics (see Williams et al., 1989). All other syllables were designated as *noncall-like* (see Figure 3 for examples).

Note that the two methods for classifying syllables are not completely independent, as all call-like syllables are by definition either stacks or downsweeps.

Statistical Analysis

Correlations, regressions, *t* tests, and descriptive statistics were computed with StatViewII (Abacus). Linear models were produced with SuperAnova (Abacus) by using Type III sum of squares, a conservative method that removes the effects of all other factors in a model before testing the factor in question.

Results

Copied Chunk Boundaries

The chunks copied by 12 young males from 1 adult tutor's song are charted in Figure 4. Although there were relatively few (12) copiers of this song, all of the syllables defined by visual inspection were copied at least twice. Only 2 of the total of 67 syllables within the tutors' songs were copied as individual syllables; the median copied chunk size was 3 syllables for this tutor (population totals; copied syllables = 612, copied chunks = 171, median chunk size = 3, modal chunk size = 3, and maximum chunk size = 13).

The example shown in Figure 4 reflects general population trends. A young male (e.g., R72) can copy some of the tutor's syllables more than once, placing chunk boundaries between different syllable pairs. Within the 5 adult males' songs, there were a total of 48 potential locations for copiers to form chunk boundaries. Actual chunk boundaries fell at 40 of these 48 potential locations. Despite this overall flexibility in locating chunk boundaries, it was clear that some points in the song were more likely than others to form chunk boundaries.

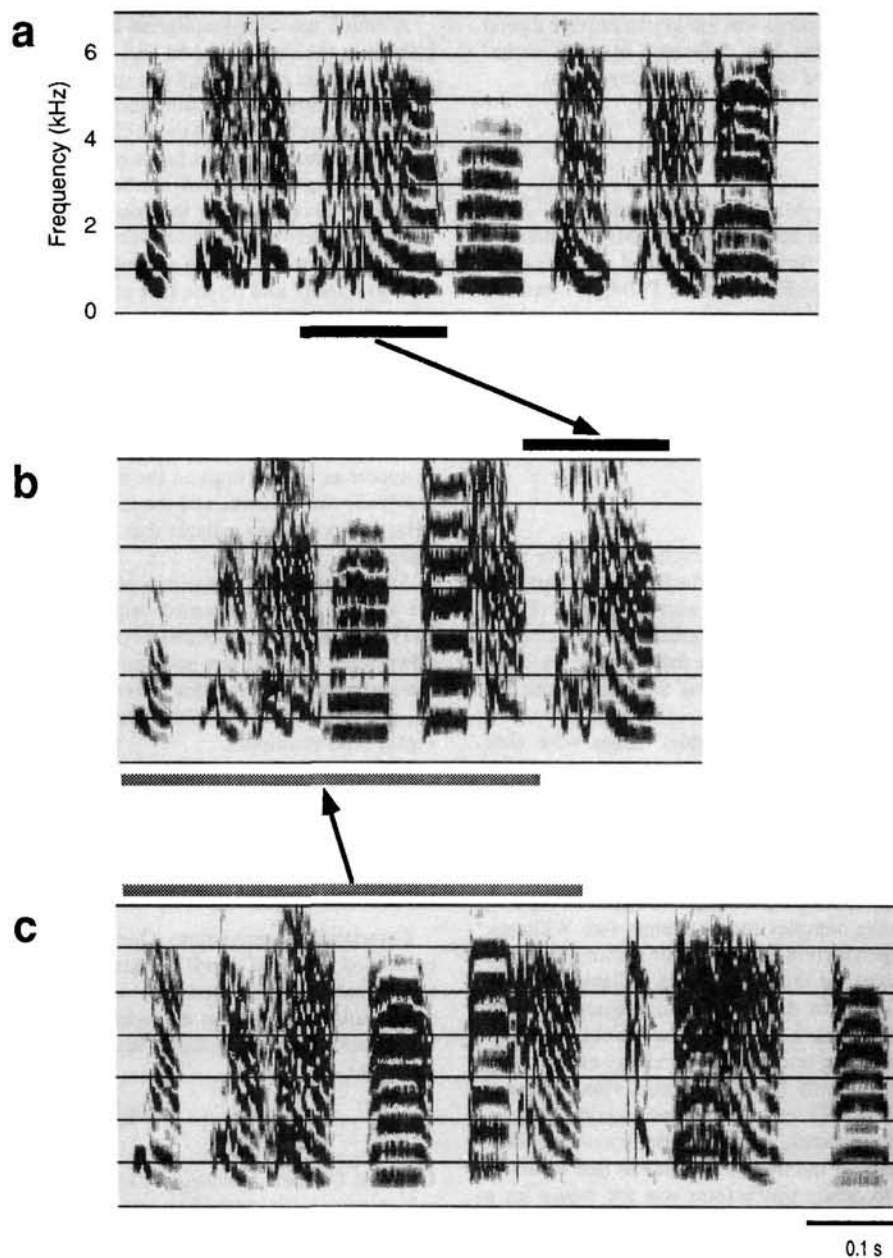


Figure 1. Young males learn chunks of tutors' song syllables. Any set of contiguous syllables copied from an adult male song and sung in the same order as in the tutor's song is defined as a copied chunk. (The song of the young male shown in Panel b is composed of two chunks: The first is the initial segment, copied from one adult, Panel c, and delivered with a faster tempo than in the model; the second chunk is copied from another adult male, Panel a, and appended to the song. It is also possible for chunks to be defined by a young male who copies syllables from only one tutor but who rearranges them to form a novel song. Each chunk defines two boundaries within the tutor's song, one where the chunk begins and one where it ends.)

Each time a syllable is copied, two opportunities for chunk boundaries occur, one before and one after the copied syllable. In the song of the adult male shown in Figure 4, a chunk boundary occurred between Syllables 6 and 7 at 10 of 14 opportunities (71%), whereas only twice in 18 opportunities (11%) did a chunk boundary occur between Syllables 2 and 3. The overall mean occurrence of chunk boundaries within the five tutors' songs was $27\% \pm 26\%$. The large standard

deviation reflects the widely differing propensity for syllable pairs to break apart and form boundaries for chunks during the song learning process.

Silent Intervals and Copied Chunk Boundaries

In the example shown in Figure 4, the chunk boundaries fell proportionately most often between Syllables 6 and 7. The silence intervening between these two syllables was longer

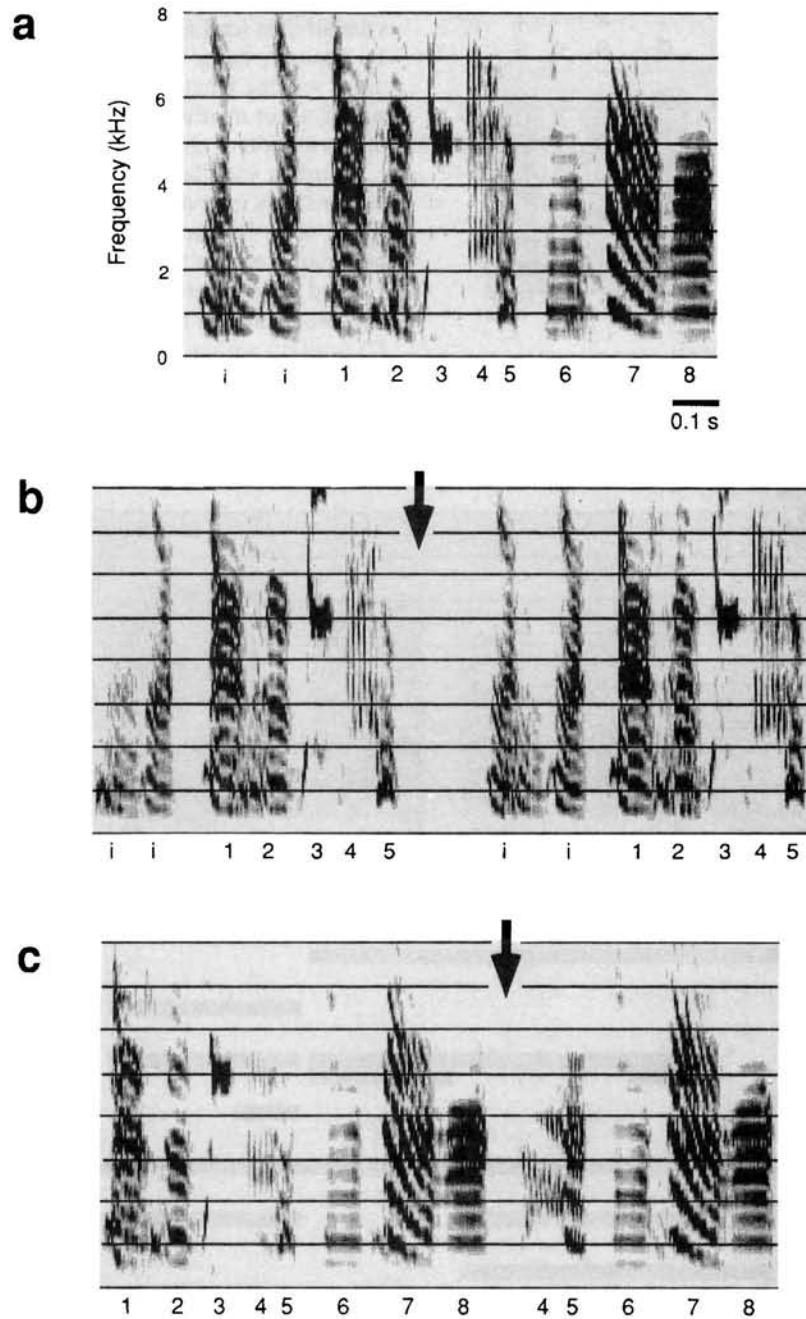


Figure 2. Breaks in production define units within a song. (The entire song of an adult male is shown in Panel a. The complete song is not always given, and breaks in production are shown by arrows in Panel b and Panel c. Such production breaks most often correspond conceptually to the ends of copied chunks, e.g., after Syllable 5 in Panel b, as the bird stops its song short. More rarely, songs will begin at points other than the first syllable and form a delivery break that is analogous to a copied chunk beginning, e.g., Syllable 4 in Panel c. Syllables 4 and 5 appear to differ from their normal morphology immediately after the production break.)

(40 ms) than the average silent interval between syllables in this song (26.7 ms). This relation proved to be generally true (Figure 5). The silent interval between a pair of syllables was strongly and positively related to the probability that, in the process of song copying, those syllables would be broken apart to form either a chunk beginning, $r(47) = .44$, $p < .005$, or a chunk ending, $r(47) = .50$, $p < .001$. The longer the interval

between two syllables, the less likely they were to be copied as part of the same chunk.

Syllable Class and Tutors' Production Breaks Affect the Location of Copied Chunk Ends

Chunks were significantly more likely to end where tutors broke their songs during production and where transitions in

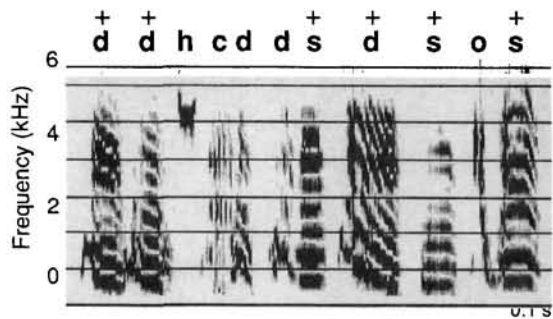


Figure 3. Example of assignment of syllable types. (Above each syllable in this song are letters to denote the syllable type: c = click, d = downsweep, h = high note, s = stack, o = other. Plus signs above letters denote syllables that were considered to be call-like).

syllable class (call to noncall and vice versa) occurred (Table 1). The only factor that affected the location of chunk beginnings was the length of the silent interval between syllables, which, as we mention before, also was significantly related to the formation of chunk ends.

As many song factors appeared to covary with the length of the silent interval, we used a linear model to determine which song factors influenced the placing of copied chunk boundaries within tutors' songs. The model shown in Table 1 tested how the proportion of copied chunk beginnings and ends were affected by five variables: (1) silent interval length, (2) position within the song, (3) whether the tutor broke his song at the point under consideration, and the class (call vs. noncall) of the (4) leading and (5) trailing syllables at the potential chunk boundary. In preliminary versions the model

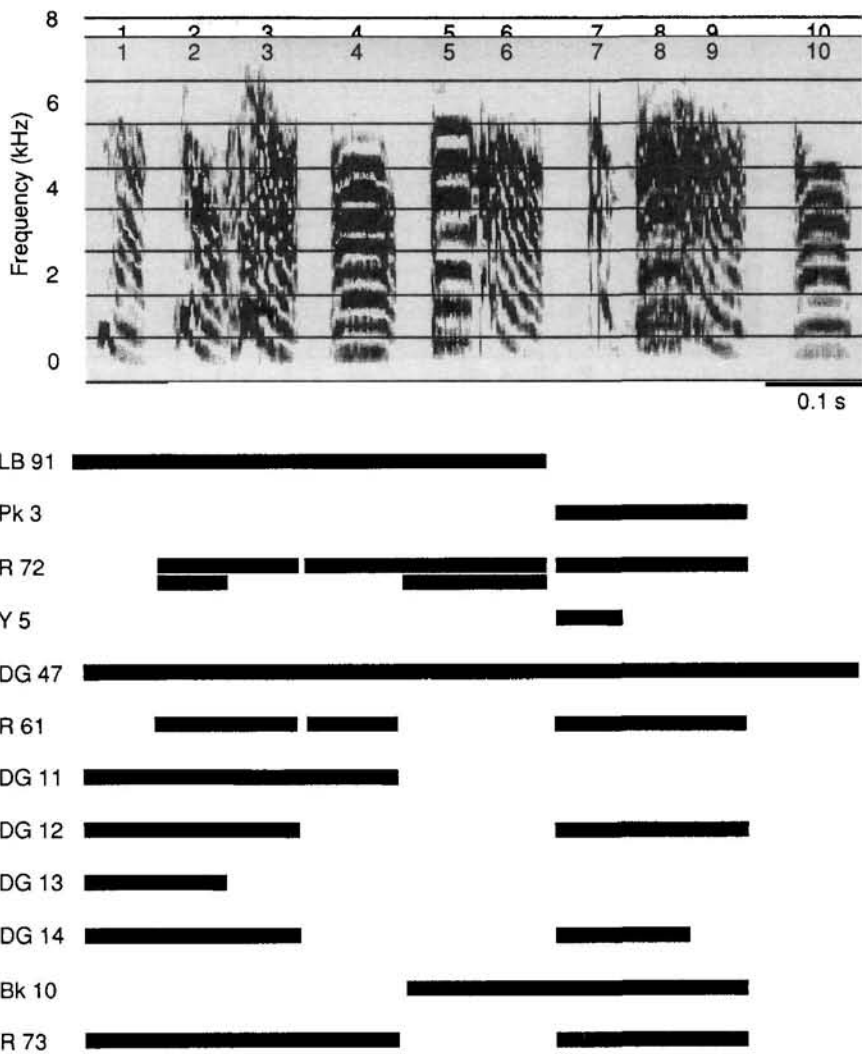


Figure 4. Chunks copied from an adult male's song. (Chunks from the song of the adult male Y, also shown in Figure 1, Panel c, were copied by 12 young males, listed here in order of hatch date. Only DG 11–14 were nestmates. Each copied chunk is illustrated by a black bar that extends underneath the syllables copied from the tutor's song. Chunks can consist of single syllables, e.g., Y 5, but most often consist of 2–5 syllables. The entire song can be copied as a single chunk, e.g., DG 47, and portions of the song can be copied more than once, as parts of different chunks, by a single bird, e.g., R 72. Note that bars that define chunks begin with the silence before the first syllable and end with the last syllable in the chunk, which reflects the results shown in Figure 6.)

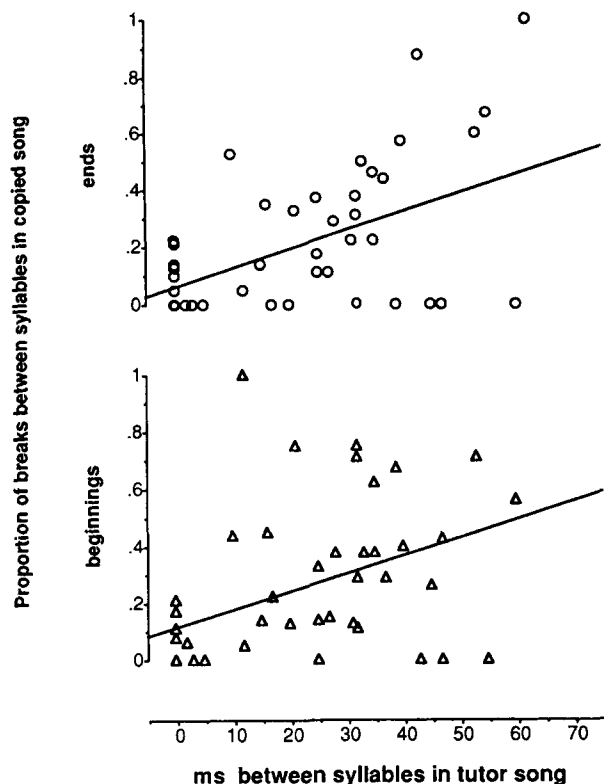


Figure 5. Silent intervals in tutors' songs and copied chunk boundaries. (The proportion of copied chunk beginnings and ends that fall between a pair of syllables increases with the length of the silent interval between the syllables. Simple regression lines are shown for each plot; they have nearly identical slopes and all relationships are significant, $p < .01$.)

also included tutor identity and syllable type (downsweep, stack, etc.), but these factors explained very little of the variance and were excluded from the final model.

The length of the silent interval between two syllables was again strongly associated with the probability that a chunk would begin or end between those two syllables. Position in the song did not significantly affect the formation of either chunk beginnings or ends. The frequency with which copied chunks began at a given point within the tutor's song was not related to either whether the tutor broke his song off at that point or whether the adjacent syllables were call-like. However, ends of copied chunks occurred significantly more often where the tutor broke his song during production and also increased significantly at any point where a call-like syllable was adjacent to a noncall-like syllable (the interaction between leading and trailing syllable). Such transitions between syllable class were relatively infrequent, as groups of call-like and noncall-like syllables tended to alternate within a song (for an example, see Figure 3).

With Which Syllable Are Silent Intervals Associated?

When a young bird copies chunks and rearranges them to form a new song, the last syllable in a chunk is separated from

the first syllable in the next chunk by a silent interval. We measured the length of this silent interval for all cases where two copied chunks immediately followed one another in copied songs and then compared those intervals to the two possible models in the tutors' songs. This allowed us to address the question of which syllable is most closely associated with a silent interval. For example, see Figure 1: Was the interval between the two chunks in Panel b copied as part of the end of the chunk from the song in Panel c or as part of the beginning of the chunk from the song in Panel a?

The silent interval between two copied chunks corresponded more closely to the interval before the second copied chunk as sung by the tutor, $r(81) = .473$, $p < .001$, than to the interval after the first chunk as sung by the tutor, $r(61) = .262$, $.03 < p < .05$ (see Figure 6). This disparity was accentuated when we removed from consideration all cases in which the silent intervals in tutors' songs is 0 ms (dashed lines in Figure 6); these were the cases in which no silent interval separated two sounds and hence they may, in some cases, be one syllable. The correlation between the silent interval between chunks and that before the first syllable in the tutor's corresponding chunk remained strong, $r(74) = .397$, $p < .001$, but the relation between the silence between chunks and that after the last syllable in the tutor's corresponding chunk disappeared, $r(54) = .016$, $p > .5$. Zebra finches learning their songs appeared to treat a syllable and the silent interval immediately before that syllable as a unit.

Copied Chunk Boundaries Become Song Production Breaks

We also investigated the relation between the processes that operate when a young male extracts and learns a chunk from an adult male's song and when he subsequently breaks his own song during delivery. Young males were significantly more likely, $t(27) = 3.763$, $p < .001$, to place their production breaks at the boundaries of chunks they had copied from adult tutors than elsewhere in the song. Even though there were more potential sites for breaks within chunks than at copied chunk boundaries, production breaks occurred more often at copied chunk boundaries (at 14.5% of opportunities) than within copied chunks (3.6% of opportunities) in the 28 young males that broke their songs during delivery.

Table 1
Variables in Tutors' Songs That Affected the Location of Copied Chunk Beginnings and Ends

Variable	Proportion of copies forming a chunk			
	Beginning		End	
	<i>F</i> (1, 40)	<i>p</i>	<i>F</i> (1, 40)	<i>p</i>
Silent interval between syllables	10.14	.003	14.32	.0005
Position in song	0.24	.6	2.63	.1
Presence of a production break	1.91	.2	15.41	.0003
Syllable class (call vs. noncall)				
Leading syllable	0.38	.5	1.42	.2
Trailing syllable	0.02	.9	2.13	.2
Leading $\times$ Trailing	1.18	.3	4.08	.05

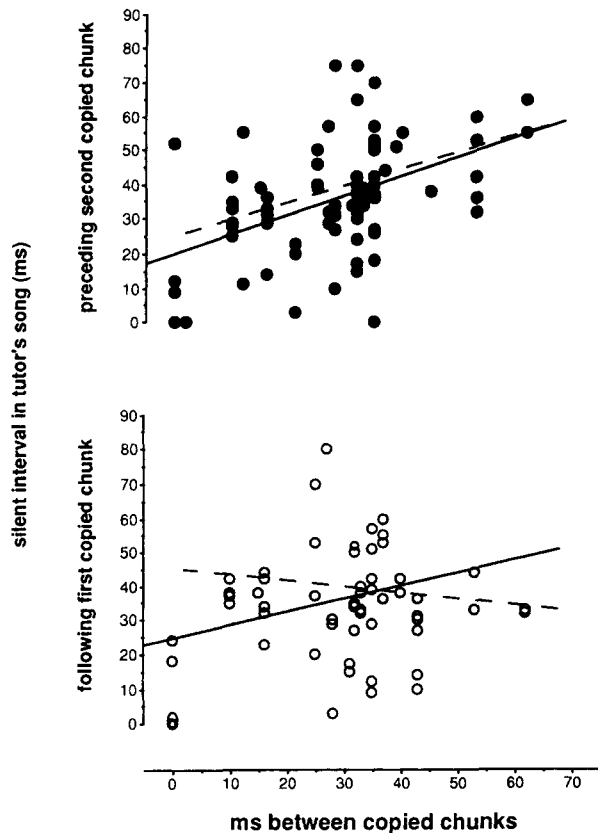


Figure 6. Silent intervals are associated with the syllable they precede. (The silent intervals between each pair of copied chunks within the young males' songs were measured and compared to the two possible models for the silent interval in the tutors' songs. The silent interval could have been copied as the beginning of the second chunk in the copied pair or as the end of the first chunk in the copied pair. Simple regression lines are shown as solid lines; although the slopes appear similar, the silent intervals in the copied song correspond more closely to the silent intervals preceding tutors' chunks, $p < .0001$, than to the silent intervals following tutors' chunks, $p < .05$. When silent intervals of 0 ms in the tutors' songs are omitted from consideration—dashed lines—the correlation between silent intervals in the copied songs and the silent intervals before copied chunks in the tutors' songs remains strong, $p < .001$, whereas the relation between silent intervals in the copied songs and those after copied chunks in the tutors' songs falls to chance levels, $p > .5$.)

Discussion

Units of song structure intermediate between the syllable and the song are not obvious in zebra finch song as neither internal repeats nor variability in arranging discrete sections of the song are present. However, the manner in which song is transmitted between generations does allow us to define intermediate structure. In copying the songs of adults, young zebra finches extract chunks of syllables from the song, add to them other chunks of syllables derived from one or more adults' songs, and then sing these chunks, strung together, as their own song. How chunks are formed and where their boundaries fall may help in understanding how zebra finches centrally represent their songs.

The boundaries of copied chunks always fell between two syllables. Although the frequency with which each syllable pair in the tutor's song was broken apart by copiers varied, chunk boundaries did fall at nearly every possible location within tutors' songs. Songs interrupted by strobe lights showed a similar pattern: Interruptions fell between syllables, interruptions occurred after any syllable, and interruptions fell most often after a subset of syllables (Cynx, 1990). These two sets of results validate the designation of the song syllables, defined by humans in visual examination of sonograms, as the smallest subunit of song both for the motor and perceptual modalities.

Boundaries between two copied chunks fell most often at relatively long silent intervals between two syllables in the tutor's song. These silent intervals correspond to mini breaths that appear to allow birds to ventilate during extended vocal performance (Calder, 1970; Hartley & Suthers, 1989). The production of stereotyped learned song has been described as the playing of a motor tape (Konishi, 1965; Marler, 1970). The extended pause between chunks may correspond to a recharging of the air sacs before embarking on a group of vocal gestures that form one subcomponent of the motor tape. As components of song production, chunks may then have a motor character similar to phrasing in speech. In humans, phrasing also serves to stress or highlight certain portions of the vocalization; it is possible that zebra finch song chunks and their boundaries may also place emphasis on subsets of syllables. A salient characteristic of zebra finch song, which is delivered at close range during courtship (Immelmann, 1969), is the widely varying amplitude of syllables—another possible mechanism for stressing individual song syllables and thereby partitioning the song into phrases.

Silent intervals are most closely associated with the syllable they precede. If forming a particular syllable requires that the vocal apparatus be moved from one specific configuration to another, the length of a silent interval could be influenced by the motor requirements of the following syllable. Although there is no direct evidence for such a phenomenon, syllables often take on slightly different morphology when their position in the song string is altered (e.g., Figure 2). Although we found no evidence of longer or shorter silent intervals associated exclusively with a certain syllable type, we cannot rule out the possibility that sound production considerations affect the length of the silence before a syllable.

There is also neurophysiological evidence that the length of silent intervals between syllables is perceptually important. The best stimulus for some song-specific neurons in the forebrain of the white-throated sparrow is defined by the silent interval between two syllables (Margoliash, 1983). Silent intervals between syllables may serve to alter the perceptual salience of the syllable independently of the sounds that compose the syllables, and our results suggest that any such effect will be associated with the syllable after a silence.

The length of the silent interval between syllables was not the only factor that affected the likelihood that a copied chunk's boundary would fall in that interval. Transitions between call-like and noncall-like syllables were especially likely to form ends of copied chunks. This suggests that these two classes of syllables differ either in how they are produced,

how they are perceived, or both. Calls can be produced by females without vocal learning (Zann, 1985), and females use a different neural pathway for vocalization than that used by males for learned song (Simpson & Vicario, 1990). Although males' calls and call-like syllables are learned, they may have a different function within the song than do syllables that are only given within learned song. Zann (1990) suggested that call-like syllables are important for kin and mate recognition. Terrace (1987) showed that pigeons organize two classes of visual stimuli into chunks when learning a sequence. Transitions between call-like and noncall-like syllables may point to chunk boundaries in a form of song punctuation.

Chunks and their boundaries are most easily defined as units of song production. Breaks in production were closely related to the ends of copied chunks, both in the tutors' and in the copiers' songs. When adult zebra finches alter their songs, entire chunks of syllables are deleted as a single unit (Williams & McKibben, 1992). Birdsong chunks as defined herein and in nightingales (Hultsch & Todt, 1989) may have a perceptual aspect similar to the chunks defined for short-term memory in humans (Miller, 1956; Simon, 1974).

Although the length of the sensitive period for song model acquisition in zebra finches is under debate (Böhner, 1990; Clayton, 1987; Eales, 1985), it has been established in other species that a song model is memorized and only reproduced after a period of up to several months during which the young bird does not sing (Marler & Peters, 1982). As well as being units of production, song chunks may correspond to what is stored or represented as a unit in memory. If this is the case, it is interesting to note that copied chunks have a modal length of three song syllables, similar to the number of items thought to comprise a short-term memory chunk in humans (originally defined as 7 ± 2 units long by Miller, 1956, but later revised to 5 ± 2 by Simon, 1974).

The general congruence of copied chunk boundaries and production breaks in the learned song is reminiscent of physiological studies that have shown that motor and perceptual modalities of song are served by the same brain areas (see Nottebohm et al., 1990, for a review). The song motor system, including the motor neurons, responds to auditory stimuli (Williams & Nottebohm, 1985); nuclei in the brain that are essential for song production (Nottebohm, Stokes, & Leonard, 1976) also have finely tuned auditory responses to portions of the bird's own song (Margoliash, 1983); respiratory centers are integrated with song motor centers (Manogue & Paton, 1982; Wild & Arends, 1987). Chunks may have both motor and perceptual aspects; that is, they are produced as a motor unit and represented in the song system of the conspecific hearer as a construct that, although perceptual, is also the basis for the motor program of learned song. Copied chunk boundaries and production breaks may then be two different observable aspects of a single internal representation of zebra finch song, one that consists of a hierarchy of units: the syllable, the chunk, and the song. The importance of the syllable as the basic unit and the song as the complete unit are undeniable and obvious. As a chunk of syllables is the unit used in transferring song between generations and in song production, it may correspond to how passerine birds internally represent strings of song syllables.

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P&C Board Appoints Editor for New Journal: *Experimental and Clinical Psychopharmacology*

In the fall of 1993, APA will begin publishing a new journal, *Experimental and Clinical Psychopharmacology*. Charles R. Schuster, PhD, has been appointed as editor. Starting immediately, manuscripts should be submitted to

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Experimental and Clinical Psychopharmacology seeks to promote the discipline of psychopharmacology in its fullest diversity. Psychopharmacology necessarily involves behavioral changes, psychological processes, or their physiological substrates as one central variable and psychopharmacological agents as a second central variable. Such agents will include drugs, medications, and chemicals encountered in the workplace or environment. One goal of *Experimental and Clinical Psychopharmacology* is to foster basic research and the development of theory in psychopharmacology. Another is to encourage the integration of basic and applied research, the development of better treatments for drug abuse, and more effective pharmacotherapeutics. To this end, the journal publishes original empirical research involving animals or humans that spans from (a) behavioral pharmacology research on social, behavioral, cognitive, emotional, physiological, and neurochemical mechanisms of drug- or chemical-behavior interaction and behavioral toxicity; to (b) descriptive and experimental studies of drug abuse including its etiology, progression, adverse effects, and behavioral and pharmacological treatment; to (c) controlled clinical trials that, in addition to improving the effectiveness, range, or depth of application, will also increase our understanding of psychological functions or their drug modulation. The journal also publishes theoretical and integrative analyses and reviews that promote our understanding and further systematic research in psychopharmacology. Although case studies are not appropriate, occasional small-sample experiments with special populations may be considered. The journal is intended to be informative and useful to both basic and applied researchers and to practitioners operating in varied settings. *Experimental and Clinical Psychopharmacology* seeks to be the vehicle for the best research and ideas integrating pharmacology and behavior.